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long would he be feeding on one or two hundred grasshoppers? But if it be intended to seduce the smaller birds to feed on these insects, in order to have an opportunity of catching them, that number, or even one half, or less, may be a good bait all winter: and all of us, who have considered these circumstances, are firmly of opinion, that these insects thus stuck up, are to serve as a bait, &c. through the course of the winter.

You will readily excuse my being so lengthy on this subject. The matter appeared to me of too much consequence to pass over hastily. I shall be glad to hear your opinion on this subject.

I send you a few of these grasshoppers, as I cut them from the trees. They being hard and dry, most of their legs broke off in taking them home.

I am, with great respect,

Dear Sir,

Your most obedient and

Humble servant,

JOHN HECKEWELDER.

N°. XIV.

An Enquiry into the Causes of the Insalubrity of flat and Marshy Situations; and directions for preventing or correcting the Effects thereof, by WILLIAM CURRIE.

Read O.G.
2, 1795. **T**HAT flat and marshy situations are unfavourable to health, and that intermittent and remittent fevers with bilious evacuations are particularly prevalent in such situations during the season of Autumn in temperate climates as well as within the tropics, has

been remarked by Physicians and Historians in every age.

But although they have agreed with respect to the fact, they have differed materially with respect to the cause of this circumstance.

A desire of ascertaining the true cause of this insalubrity induced me to engage in the enquiry which I am now about to submit to this respectable society, and I hope the time and attention which I have bestowed upon a subject so interesting to mankind, will not be deemed labour misemployed.

The atmosphere in salutary situations, has been demonstrated by Mr. Lavoisier and his colleagues, to be a compound body consisting of two distinct gases or aeriform fluids, the one called azote or nitrogen gas, and the other oxygen-gas or pure respirable air; and that in one hundred parts of the atmosphere, the proportions of these gases are 72 of the azote and 28 of oxygene, or as three to one.

From Mr. Vanbreda's experiments, on the atmosphere of marshes in the autumnal season, which he subjected to the common test of nitrous air in the eudiometer, it appears that these proportions were very different; there being but 14 or 15 parts of oxygene, to 84 or 85 of azote, but that the bulk was supplied, and the same weight preserved by a certain quantity of carbonic gas or fixed air, and a small portion of hydrogen and ammoniacal gases or aeriform fluids.

All these gases are the effects of vegetable and animal putrefaction, and must be derived from the soil, or the vegetable and animal substances connected with the soil.

The soil of marshes is composed entirely of vegetable and animal substances, which have undergone the process of putrefaction, and consists principally of vegetable earth, carbon or charcoal and nitre, mixed with more or less

less calcareous and argillaceous earth, and by distillation affords oil, hydrogen, and azote.

From this soil, and from the various vegetable and animal substances mixed with it, and constantly putrefying in hot weather, it has been supposed miasmata issue, which give origin to the diseases peculiar to marshy situations; and as there are no substances but those gases, already enumerated, which can be discovered to issue from a marshy soil, or from putrefying vegetable or animal substances, if those diseases depend upon miasmata or effluvia, these miasmata must consist of one or more of the gases enumerated.*

In order to determine this matter, it will be necessary to enquire into the effects which these substances, singly, or combined, usually produce on the living human body.

If the carbonic gas or fixed air, when applied in a certain quantity or in a concentrated state, destroys life instantly by its action on the irritability of the muscular fibres of the heart, as from the observations of Messrs

* "In the vinous fermentation, part of the principles of the vegetable substance, viz. the hydrogen, remains united with a portion of water and of carbon to form the alcohol.

"In the acetous fermentation, a union takes place between the oxygen and the alcohol, and earthy matter is deposited. In other words the base of the pure air absorbed, uniting with the alcohol of the liquor, and the essential salts dissolved in it, forms vinegar, while a deposition takes place of earthy or oily matters no longer soluble in the liquor. Hence vinegar is in an intermediate state between wine and fixed air, accordingly vinegar may be made by impregnating alcohol and water with fixed air.

"The gas of fermenting liquors which is fixed air, holding some spirit of wine in solution received into water, has the same effect.

"In the putrid fermentation (which is the only species that takes place in marshes,) the whole of the hydrogen is dissipated, under the form of inflammable gas, while the oxygen and the carbon uniting, with the caloric or principle of heat, escapes under the form of fixed air," after this process, if there has been sufficient water and heat to complete the putrefactive process, nothing remains but the earth of the vegetable, mixed with a little carbon and iron.

Chaptal.

Priestley,

Priestlley, Bergman, Fontana, Cavallo, and other Philosophers of credit, appears to be the case, nothing is more probable than that a less quantity though much weakened by diffusion in, and mixture with, the atmospheric air would operate in a similar manner, though in a less degree, and occasion a disease of a paralytic or insensible kind, and not an intermittent or remittent, since in these last the sensibility and irritability are manifestly increased.

* That the hydrogen gas or inflammable air, has little or no share in the generation of the diseases under consideration, is rendered evident by the experiments of Chaptal, De Rosier, and Beddos.

The former assures us, that he inspired it several times, without perceiving any effect from it, and that it returned from his lungs without any alteration either in weight, bulk or quality, whereas common atmospheric air suffers a very material change by respiration, its pure or oxygenous portion being abstracted, and the remainder rendered incapable of supporting flame, and unfit for respiration.

De Rosier not only inspired inflammable air, but applied flame to it as he discharged it through his nostrils, without receiving any injury from it. He also discharged the burning gas from his mouth through a tube, so that he appeared to breath flame.—No detonation took place in his mouth, because he had discharged all the atmospheric air from his lungs, before he inspired the inflammable air.

Dr. Beddos prevailed on a stout florid young woman, to inspire hydrogen for two minutes, without any per-

* It appears from the experiments of Mr Lavoisier, that hydrogen is always the result of decomposed water; and that water is a composition of hydrogen and oxygen kept in a fluid state by its union with caloric and consists of 85 parts in 100 of oxygen and 15 of hydrogen.

ceptible

ceptible effect, except a slight giddiness after she had descended a flight of stairs.

No alteration is made in their properties by the mixture of carbonic with hydrogenous gas. No decomposition takes place, no caloric is set at liberty or heat rendered sensible by such union. We may therefore from what has now been stated, conclude that neither carbonic nor hydrogen gas, singly or combined is the miasma or effluvium by which the diseases in question are produced.

In consequence of the putrefaction of farinaceous plants, and all such as abound more in gluten than in the saccharine, or mucilaginous principles, as well as from the putrefaction of animal substances, an ammoniacal gas is produced, owing to the union of the hydrogen, evolved in the putrefactive fermentation, with the superabundant azote of the atmosphere.* But this gas instead of diminishing the powers of the human body, is well known to have a contrary effect, except when received into the lungs in a large quantity, and then it proves destructive from its stimulating quality, inducing a spasm on the glottis or bronchiæ. That neither the water of marshes, nor the exhalations which arise from thence, are septic or promoters of putrefaction, has been fully demonstrated by the experiments of Dr. Alexander.†

* Does the union of dead animal and vegetable substances prevent the noxious effects of each other?

† Having filled a tea cup with putrid water taken from a ditch in the meadows on the south side of Edinburgh, (which in summer contain a considerable quantity of extremely putrid stagnating water), and another cup with pure water, "I put a bit of mutton into each cup and set them together in the open air. The mutton in the pure water began to putrefy in about 36 hours. At the end of three days, that in the marsh water was quite sweet. On the 5th day it was taken out washed carefully with pure water, and found perfectly sweet. That in the pure water was now become intolerably fetid, and on that account was thrown away. The 7th day the mutton in the marsh water was washed again, and found as fresh as before. When it had lain in about six weeks, it still continued perfectly sweet, and the liquor around it of the same smell and colour as at first

But that any exhalation or other substance, should act on the moving powers or solids of the human body several days after it has been received into the body, without making some material change in the condition or quality of the circulating fluids is inadmissible because it is scarcely conceivable. That such alteration is made in the quality of the fluids in putrid fevers is manifest from the contagious effects of the several excretions. But in cases of intermittents and remittents which originate in marshy situations, no such evidence is afforded, for there is no authentic instance of these being contagious or communicable from one to another.

As no other exhalations or noxious matters than those which have now been enumerated, can be discovered in the most unsalutary atmosphere of marshes; as there is no source from whence any other noxious substance can be introduced into the atmosphere of such situations, and as it is evident from the known effects of the gases which have been discovered in it, that they can not have the effect of producing the diseases under consideration either when applied singly or united, we certainly ought to hesitate before we adopt the doctrine heretofore taught, respecting marsh miasma.

But as it is well known that a very material alteration is made in the proportions, which one of the component parts of the atmosphere bears to the other, by certain processes of nature and art, let us enquire how far the alteration which is made in the atmosphere of marshes, by the process of putrefaction may affect the present question.

first. After two months, things were exactly the same. The mutton was then thrown out." Alexander's Experimental Enquiry, p. 71.

From the experiments of the same gentleman it appears, that pieces of dead flesh suspended over the exhalations of the putrid water of marshes, are five or six days longer putrefying, than those suspended over the exhalations of pure water. (See his 15th & 17th experiments).

Mr. Vanbreda's experiments, prove that there is less oxygen in the atmosphere of marshes during autumn when the weather is dry and hot, than in more salutary situations, and it is well known from innumerable experiments made by different philosophers, that this can only be diminished by combustion, fermentation putrefaction or respiration, or a process of a similar kind.

It is also a fact fully established, that the functions of life as well as the process of combustion and fermentation can only be continued by the application of oxygenous gas, and that these are affected in proportion to the quantity and purity of the gas applied.

It was formerly discovered by Vefalius, and has since been confirmed by the observations of Drs. Lower, Priestley, Crawford and others, that the blood in the pulmonary veins is of as red and florid a colour as in the arteries, which is the reverse in every other part of the system. This circumstance has been demonstratively proved to be owing to the action of the oxygen, or the base of pure air upon the blood in the pulmonary veins.

From the experiments of the discerning and ingenious Dr. Goodwin upon living animals, it appears, that the action of the heart cannot be continued by the reception of blood, which has not undergone this change of colour in the pulmonary veins from the application or introduction of oxygen. This fact has been since confirmed by the experiments of Dr. Girtanner, as may be seen in his Essay on the principle and laws of irritability.

That blood impregnated with oxygen, or the base of pure air is the necessary, and appropriate stimulus for giving motion to the heart, and enabling it to carry on the circulation of the blood was rendered evident from the gradual diminution and debility of its contractions, as the colour of the blood became darker when the pure air was excluded, and from its contractions becoming stronger

as the blood recovered its florid colour from the application of pure air.

In these experiments, all the other functions of the body were observed to be proportionally affected with the heart. As its contractions diminished, the power of these also declined: As the power of the heart recovered, these also recovered.

By these experiments, we learn that the abstraction or exclusion of the oxygenous part of the atmosphere, in a given space is sufficient of itself to deprive animals of life by withholding the cause of action. Hence we are authorised by the chastest rules of induction to conclude that health and life must be affected more or less in proportion to the quantity of this vivifying principle at any time abstracted from the atmosphere, which more immediately surrounds us.

The presence of the other component part of the atmosphere, the base of the azotic gas though totally opposite to the oxygen with which it forms a perfect compound, and neutral substance when mixed in the proportions already mentioned, appears to have no share in destroying life, though its name is derived from a mistaken supposition that it had that effect; for the heart immersed in this gas, will retain its irritability several hours, in a warm situation, after all signs of life have disappeared in the rest of the body. Mr. Valli's experiments on animal electricity have established this fact.

Carbonic gas or fixed air, on the contrary, produces its destructive effects by a direct operation, for it destroys the nervous power and the irritability of the muscular fibres the instant that it is received into the lungs, and comes in contact with the heart.

If the carbonic gas operated, as suggested by Mr. Kite, by inducing a spasm of the glottis and thereby excluding the atmospheric air, the heart as in other cases of suspended

pendent respiration would retain its irritability for some time ; but this is not the case.

From the facts and observations which have now been stated, I think it may be fairly concluded, that the causes of the unwholesomeness of low and moist situations in the summer and autumnal months, is not owing to any invisible miasmata or noxious effluvia, which issue from the soil and lurk in the air, but to a very different cause, viz. to a deficiency of the oxygenous portion of the atmosphere in such situations, in consequence of vegetable and animal putrefaction, in conjunction with the exhausting, and debilitating heat of the days, and the sedative power of the cold and damp air of the nights.

For want of the refreshing and salutary stimulus of pure air, all the functions of the body are performed imperfectly and languidly. The nervous system in particular, becomes preternaturally susceptible of impressions from every change that occurs in the temperature of the surrounding atmosphere. The application of or exposure to a damper and colder state of the air than usual, renders the vessels on the surface of the body powerless, and atonic, the brain and heart sympathise with the extreme nerves and vessels, the power of every function of the body declines, till the heart roused by accumulating blood reacts with increasing velocity, and is relieved of the unusual burthen.

That the causes which I have now assigned, are the true ones is rendered next to certain, from the frequent occurrence of those diseases, (which have heretofore been supposed to depend upon the operation of specific miasmata), in situations remote from marshy ground, particularly in large and populous cities, where sedentary occupations and want of exercise, render the inhabitants delicate and infirm. I have seen numerous instances of this kind even in the winter season, when no effluvia from marshes

could possibly exist, especially among those who had been previously debilitated by other disorders. Nor is it uncommon for persons who have recovered from intermittents in the autumn, to have frequent recurrences of the same disease in the winter, merely from sitting in a damp room, or other exposure to cold.

In persons much reduced by the diseases of autumn, it is also very common when attacked with the inflammatory diseases of winter, for the system to resume its customary habits of action, and for the fever to resemble an intermittent in the time and manner of its exacerbations, and remissions, and immediately after the removal of the local affection to become a regular intermittent. This is so generally the case on the eastern shore of Maryland, that the physicians in that country seldom make much use of the lancet in any of the diseases which occur there, except in the spring season. Are we not authorized from these facts to infer, that any circumstances which occasion a certain state of debility, and irritability in the vessels and nerves on the surface of the body, and in the sensorium at the same time, are predisposing causes of the diseases, we are now considering, and that when the system is in this condition by whatever cause induced, the sudden application of cold, terror, or any other suddenly debilitating power, may become the exciting or occasional cause of febrile disease, in an indirect manner by repelling the blood to the heart, lungs and brain, and forcing them to react by the stimulus of distension?

If the diseases of marshy situations were produced by a specific matter, they could never be produced by any other cause, but as they are frequently induced in seasons and situations, where that supposed specific matter or miasma cannot possibly exist, there is nothing more clear than that they are not produced by any such specific matter.

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The opinion that those diseases, are the product of specific matter generated by vegetable putrefaction, appears to be rendered groundless from the disease varying in its type and symptoms, in proportion to the extent and putridity of the soil, state of climate, season and weather with respect to heat, moisture, &c. and also, in its not being contagious, the reverse of which is the case with all known diseases that are derived from specific matter.

We are assured by the accurate Monro, in his account of the diseases which prevailed in the military hospitals in Germany, in 1761 and 1762, that the intermitting fever seldom attacked any but those whose solids had been previously relaxed by the preceding heat of the summer, except when they had been fatigued and overheated by the sun and afterwards exposed to the evening dews.

Dr. Lind of Windsor, says, sudden exposure to cold occasioned either an inflammatory fever or a simple intermittent at Bengal, according to the predisposition of the body.

The scurvy as well as the diseases already enumerated also appears to derive its existence from a deficiency of pure air in conjunction with a cold and moist atmosphere, and a diet of salted flesh meats. For it generally prevails in long voyages after a continuance of wet weather. The hatches being kept shut at such times, prevents ventilation, in consequence of which the oxygen becomes exhausted.

Captain Cook in his two last voyages preserved his crew from the scurvy by frequent ventilation, constant cleanliness, suitable cloathing, and strict discipline.

Dr. Trotter assures us that in a slave ship of which he was surgeon, the seamen that were constantly on deck, and fed with the ordinary sea diet remained free from
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the scurvy, while the slaves that lived principally on vegetables, but breathed a confined impure air fell miserable victims to it.

The remarkable case of the blue boy, described by Dr. Sandifort of Leyden, furnishes another striking example of the importance of oxygen in the preservation of health and life, as well as a confirmation of its being the cause of the red colour of the blood.

In this boy, whose skin was as blue as indigo, the aorta communicated with both ventricles of the heart, in consequence of which the greatest part of the blood was immediately propelled from the right ventricle into the aorta, so that very little passed into the pulmonary artery to be oxygenated.

An opinion equally erroneous with that which has lately prevailed respecting the causes of intermittent fevers, &c. has also been delivered down from age to age, respecting the causes of continued fevers of the nervous or putrid kind.

The doctrine formerly taught respecting these, was that they derived their existence from the effluvia of dead and putrid animal substances: but from more recent and accurate observations, it appears that the contagion by which this kind of fever is produced as well as those of a pestilential nature, is always derived from the living human body in confined and unventilated situations, and it is probable that the effluvia thus excreted, partake of the quality of nitrogen gas, from their being rendered harmless by a union with oxygen or the base of pure air.

It appears more than probable also from the history of the circumstances always present at the time febrile contagion is generated, that it is rendered virulent and powerful in proportion to the absence or defect of oxygen and the degree of heat to which the living body
has

has been exposed in such situations. It was a concurrence of these circumstances which gave origin to the yellow fever which appeared in Grenada in the beginning of the year 1793, and which was afterwards imported into Philadelphia, as appears from the account published by Dr. Chisholm.*

Noxious effluvia indeed frequently arise from putrid animal substances in confined situations. Dr. Monro mentions a remarkable instance of this, and some later examples are recorded by Mr. St. John; but it does not appear from these cases that those noxious effluvia produced any symptoms, resembling those of putrid or pestilential fevers; on the contrary they acted as direct stimulants, and occasioned inflammatory affections without being preceded by that sense of debility which always precedes those fevers that are occasioned by febrile contagion.

Having now shewn, that the diseases which prevail most generally during the autumnal season in low and marshy situations, owe their origin, not to invisible exhalations or miasmata, but to the causes which I have assigned, the prophylaxis, or the means of preventing the occurrence of those diseases must be simple and obvious.

These are to introduce and increase the proportion of oxygenous gas in the superincumbent atmosphere, and to prevent its future abstraction, by cutting off or diminishing the sources of putrefaction.

It would be a happy circumstance if the application of the means suited to produce an amendment in a body so large and fluctuating as the atmosphere, was as practicable as the means suited to effect that purpose are obvious: but unfortunately, this requires too much labour and expence to admit of extensive application, especially

* Vide Chisholm's Essay on the fever of Grenada in 1793 &c.

in a country where population and wealth do not bear a due proportion to the extent of territory.

We ought however to attempt every thing in our power to effect so desirable and useful an event.

Chemistry furnishes various articles by means of which we can generate and introduce a supply of oxygen into the atmosphere, as well as alter the quality of those noxious gases with which it is occasionally contaminated.

These however can only be employed in a very limited and partial manner, and of course can only produce a limited and partial amendment.

I shall therefore mention only a few of the substances that may be occasionally employed for this purpose.

A large portion of oxygen may be furnished by the decomposition of nitre, as is demonstrated from its maintaining the combustion of inflammable bodies.

If lighted charcoal, be placed in a proper exposure to the open air it will continue to burn till the whole be reduced to ashes.

If nitre be mixed with charcoal, and when kindled placed in a close vessel, the combustion will continue as well as if exposed to the open air; whereas, without the assistance of the nitre, the charcoal would be immediately extinguished in that situation for want of a supply of oxygen.

Mr. Schele by heating nitre to red heat in a retort, received into a moistened bladder more than fifty ounces in measure of oxygen gas from one ounce of nitre. A pound will therefore furnish 800 ounces.

Nitre ground with two thirds of its weight of mintum and moistened with water so as to form a paste, burns very rapidly and emits a considerable quantity of pure air.

But the grand engine, by which, the sources that deprive the atmosphere of its salutary and vivifying principle,

ple, are to be cut off; and the great magazine, from whence a sufficient supply is to be obtained, must be fought for in the art of agriculture.

The stagnant waters may be carried off and the soil of marshes rendered dry, by means of drains, deep trenches, and wells; and farther stagnation and putrefaction prevented, by consuming the dead weeds, grafs, and woods, and by filling up the flats, sinks and hollows with clay, sand, or lime.

And the atmosphere may be supplied with a profusion of oxygen by cultivating on such soils, grafses and plants of vigorous growth, and especially those which live and flourish latest in the season. For vegetables while living and growing, when exposed to the rays of light constantly decompose the water they imbibe from the earth and air, and while they retain the hydrogen or base of inflammable air for the formation of oil, wax, honey, or resin, they replenish the atmosphere with oxygen.”*

When it is impracticable to render marshy situations dry, on account of their extent, they should be kept constantly flooded by means of dams and sluices, to prevent the effects of putrefaction, for when dead vegetable or animal substances are immersed in water so as to be entirely excluded from contact with the air, putrefaction can only take place in a slow and imperfect manner.

But clearing the woods, plants, and herbs, from marshy or fenny tracts without draining off the stagnant water at the same time, and destroying the dead herbage by fire, instead of rendering such situations more healthful has been found to have a different effect, because a greater extent of putrescent surface is thereby exposed to the rays of the sun, and of course a greater portion of oxygen abstracted from the atmosphere. It is owing in

* Chaptal's Chemistry. Ingenhaufz's Observations, &c.

great measure, to this circumstance, that all new countries are so generally fatal to the first settlers.

The same land after it has been cultivated a few years, especially if there be sufficient declivity to prevent the water from stagnating, loses its unwholesomeness, the putrescent substances mixed with the soil or superficial stratum of the ground having finished the putrefactive process by that time. In order therefore to render and preserve marshy countries healthful, they should be preserved dry and clean by means of the spade, the plow, and the rake.

When the level situation of a place prevents the stagnant water from being carried off by drains, deep wells should be dug, in different places for the water to collect in, by which means a greater portion of the soil will be rendered dry, and less noxious.

To prevent still farther the injurious effects of residing near marshes or mill ponds : rows of such trees as grow rapidly, and retain their verdure late in the season, should be planted between those situations and the mansion, for the purpose of intercepting the moisture in its progress, while they furnish a constant supply of oxygen to the atmosphere.

Lodging in the upper story of a house has been found to preserve health during a sickly season, instances of which are recorded by Sir John Pringle. This appears to be owing to those situations being out of the reach of the moisture from the ground.